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Bashkirian train–gas pipeline disaster: the American military response

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The United States Army Institute of Surgical Research was asked to provide burn care assistance in June 1989 following the explosion of leaking methane/propane gas in the Central Soviet Union, which destroyed two passenger trains and injured 800 passengers. A 17-member burn team flew from San Antonio, Texas, to Ufa, USSR and assisted in the management of 150 burn patients in a general medical-surgical hospital. Early problems included heavily colonized burn wounds, with a microbial flora that demonstrated broad antibiotic resistance. As wound complications were controlled, 28 operative procedures were performed to excise and graft the burn wounds. The recommendations for burn disaster management, based on our experience in Ufa, should be of assistance to other groups that may be asked to provide similar assistance in the future.

Introduction

Patients with major thermal injuries are best cared for at a centre which specializes in the management of burn patients, under the care of surgeons with expertise in burn management (Pruitt, 1980). Most thermal injuries occur on a sporadic basis and involve only one or a few casualties. Under these circumstances, patients can usually be referred to a burn centre without difficulty. The widespread distribution of highly flammable petrochemical products, often situated close to population centres, and the concentration of large numbers of people in hotels, ships and other structures have increased the probability of disasters which generate large numbers of casualties with thermal and/or inhalation injuries. The frequency of such disasters appears to be on the increase. Recent examples include the Ramstein Air Show disaster in the FR Germany, the MGM Grand Hotel fire (Buerk et al., 1982), the Los Alfaques disaster (Arturson, 1981) and others. When such a disaster occurs, it may overwhelm the local community's, or even the country's ability to provide specialized burn care. Should this occur, an international effort to provide additional medical and surgical support to the involved area may be the only way to provide the resources needed to avoid unnecessary death and disability.

Although there are a number of civilian organizations dedicated to providing international humanitarian medical relief following disasters, many of these organizations lack the financial and logistic support to provide effective surgical support to large numbers of burn patients following a disaster. Because of several unique characteristics, military medical and surgical teams may be an effective solution to the problem of rapidly providing long distance transfer of skilled medical personnel and supplies to remote areas following a manmade or natural disaster. Many countries, including the USA, have invested substantial resources to maintain the capability of rapid, long distance transport of physicians, medical support personnel, and medical supplies and equipment in the case of conflict. In modern warfare, 5–20 per cent of battle casualties will sustain burn injury; therefore an effective military medical corps should have the resources in place to respond rapidly to a disaster generating burn casualties (Eldad and Torem, 1990). Also, military surgical units have direct access to aircraft suitable for long distance aeromedical transport (Cioffi and Pruitt, 1989). Sufficient financial resources to support a relief effort are less likely to be a major problem for military versus civilian organizations.

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Bashkir train disaster

On 4 June 1989 a leak developed in a natural gas pipeline in the Soviet Republic of Bashkiria, just to the west of the Ural mountains. As the pressurized gas leaked from the pipeline, it expanded and enveloped a nearby railroad line. Late that evening two passenger trains crossed in the area of the gas leak and ignited the gas, which exploded, causing severe damage to both trains. The explosion and ensuing fire injured or killed most of the approximately 1300 passengers on the trains. Approximately 400 passengers were killed in the accident and 80–90 per cent of the survivors had mechanical or thermal injuries, or both. Triage and transport of the casualties were performed by medical disaster teams mobilized from nearby rural hospitals and medical clinics, and from Ufa, the capital of the Bashkirian Republic, approximately 120 km away from the accident site. Because of the rural location of the accident (20 km from the nearest paved road), transportation of casualties was difficult and was accomplished primarily by rail and helicopter. Patients were initially moved to local hospitals and then to hospitals in Ufa and Chelyabinsk, the nearest urban centres.

On 8 June 1989 the government of the USA received a formal request from the government of the USSR for medical assistance in the care of burn patients from this accident. In response to this request, the Joint Chiefs of Staff of the United States Department of Defense directed the United States Army Institute of Surgical Research (USAISR) to

Figure 1. Medical supplies being unloaded from a US Air Force C-141 cargo plane in Ufa.

assemble a burn team and necessary supplies and to proceed to the USSR to provide the requested assistance. The USAISR, which provides burn care to US servicemen and their families, has established burn teams to stabilize and transport burn patients to the burn centre in San Antonio, Texas. A burn team composed of 17 medical personnel (three surgeons, three registered nurses, six practical nurses, three respiratory therapists, one microbiologist and one laboratory technician) was organized and 7000 kg of medical and surgical supplies were obtained. Transportation for the team and supplies was provided by the US Air Force, using a C-141 transport aircraft (*Figure 1*). Additional personnel, including two administrative officers and three translators, joined the burn team in Washington, DC. Electric power requirements in the USSR had been determined and six MA-1 ventilators compatible with the power supply in the USSR were obtained from the United States Army 7th Medical Command when the transporting aircraft stopped for refuelling in Frankfurt, FR Germany. The burn team then flew to Moscow, where immigration formalities were completed. At that point the team was directed by Soviet authorities to fly to Ufa to provide assistance in that city. A Soviet navigator joined the cockpit crew for the flight to Ufa and the team and supplies arrived in Ufa on 11 June, 45 hours after the request for assistance had been received at the USAISR.

In Ufa, the team was assigned to Hospital 21, a large general medical and surgical facility with minimal previous experience in the management of burn patients, to assist the local medical staff in the care of patients from the accident. Hospital 21 received 150 patients from this accident; 95 per cent of these patients had thermal injuries. The burn team was divided into a microbiology laboratory group and three separate clinical teams, each composed of a surgeon, a registered nurse, two practical nurses and a respiratory therapist. We estimate that a clinical burn team of this composition can provide initial care for up to 50 burn patients. In addition to the local medical staff and the burn team, a physician from the Bashkir Burn Center was assigned to assist in the management of patients in this hospital. Translators, from local universities and technical institutes, were provided to supplement the translators brought with the team. Adequate and effective translation capabilities were essential as no member of either the burn team or the hospital staff was fluent in both Russian and English.

Patient management at this time was primarily directed to care of the burn wound. Most of the wounds had received minimal attention for several days and were at least heavily colonized by a flora in which pseudomonas and staphylococcus species predominated. Several patients had developed invasive pseudomonas burn wound infection (*Figure 2*) and were placed on broad-spectrum intravenous antibiotics (amikacin and pipericillin) in addition to topical chemotherapy. Because of the heavy wound colonization, mafenide acetate was the topical chemotherapeutic agent used in patients with extensive burns. Patients with small, clean wounds were treated with silver sulphadiazine as a topical agent. Many of the patients also had associated mechanical injuries, predominantly soft tissue lacerations, caused by flying glass and metal during the explosion. These wounds were debrided, cleansed and explored for removal of foreign material (*Figure 3*). All patient management decisions and procedures were the result of close collaboration with the hospital medical and nursing staff. A substantial portion of the burn team's efforts was devoted to educating and training the hospital staff in burn management techniques, so that the local medical community could assume increasing responsibility for the care and management of the patients. The medical staff, including general and thoracic surgeons, anaesthesiologists and intensivists (reanimationologists) were enthusiastic in their efforts to learn and provide the burn management techniques practised by the USAISR burn team.

The microbiology component of the USAISR burn team consisted of a microbiologist and a laboratory technician. This two-man team was supplied and equipped to provide microbiology support, including sensitivity testing for the antibiotics brought with the US team (amikacin, vancomycin, ceftazidime and pipericillin). The team transported sufficient material to perform approximately 1000 antibiotic

Figure 2. Burn wound of lower extremities demonstrating changes of pseudomonas burn wound infection.

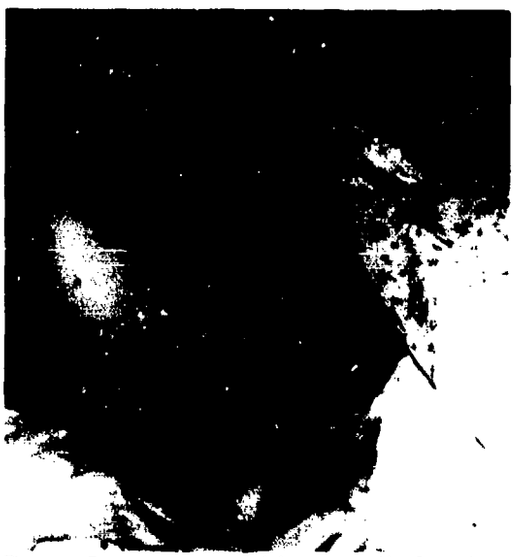

Figure 3. Penetrating injury of abdomen caused by flying debris associated with the propane gas explosion.

sensitivity tests and strain identifications. The antibiotics transported by the American team were not previously available in Ufa and the Hospital 21 laboratory could not initially test their activities. Within 2 days of arrival, the essentially uniform and probably unavoidable cross-contamination of the patients was obvious. The major infecting organisms, *P. aeruginosa* and *S. aureus*, were commonly resistant to all locally available antibiotics (penicillin, ampicillin, gentamicin and methicillin) (*Table 1*). The development of resistance to the antibiotics brought with the USAISR team was not observed.

Local surgical practice generally did not include early surgical excision of the burn wound. Because of the location of many of the burn wounds, predominantly on the hands, feet and upper extremities, it was our feeling that an aggressive surgical approach was warranted to enhance the functional outcome. To assist in the intraoperative and postoperative management of these patients, additional manpower including an anaesthesiologist experienced in burn surgery, a surgical technician, a physical therapist and an occupational therapy technician, were flown from the USAISR to Ufa several days after the team arrived. During the first 2 weeks following the arrival of the burn team, 28 patients were selected to undergo burn wound excision, either tangential or at the level of the investing fascia, with the immediate placement of split-thickness autografts (*Figure 4*). Because of the difficulty in obtaining sufficient quantities of adequately cross-matched blood for these procedures, arterial tourniquets were used, whenever possible, in combination with topical vasoconstrictors and thrombin spray solutions to minimize intraoperative blood loss. All operative procedures were performed by combined Soviet–American surgical teams. A partial list of the operative supplies brought by the USAISR team to Ufa is given below:

- Dermatomes – 4 electric
  4 air driven
- Skin meshers – 4
- Weck blades and handles – 300 blades, 10 handles
- Portable field anaesthesia machine – 1
- Pulse oximeter – 1
- Topical thrombin spray – 100 packages
- Epinephrine 1 : 1000 – 50 1-ml vials
- Disposable gowns and gloves – 10 cases each

Postoperatively, the grafted areas were kept covered for 5–7 days with gauze dressings to which a 5 per cent mafenide acetate solution was applied to decrease microbial proliferation. Splints fashioned for each patient by the occupational therapist were used to immobilize the grafted areas. After the dressings were removed, a vigorous programme of physical therapy was designed for each patient to maximize mobility and function of the grafted areas.

Figure 4. Tangential excision of upper extremity performed by joint USA–Soviet surgical team.

The majority of the burn team returned home after 2 weeks in Ufa; however, a small contingent remained in Ufa for another 2 weeks to assist with the postoperative care and rehabilitation of patients cared for following this accident.

The cost of supporting a medical relief effort such as the one described here is substantial. The costs associated with our mission are listed in *Table II*. The costs listed do not include the cost of the transportation provided by the US Air Force, which was estimated at $300 000. It should also be noted that *Table II* does not include the salaries of the team members.

International relief efforts

Based on our experience with this and other mass casualty burn disasters, we offer the following recommendations for those who are involved with the planning of international relief efforts, or who may be asked to provide similar assistance in the future:

1. A disaster management plan should be formulated and in place prior to receiving a call for assistance. This plan should include a roster of available personnel and suitable alternates. A general description of team size and composition should be included. Teams can then be expanded depending on the estimated number of casualties. A source of translators should be developed. For international relief efforts, all proposed team members should have valid passports. The location and availability of equipment and medical, laboratory and surgical supplies should be determined. The ability of local resources to support laboratory, chemistry and microbiology requirements should not be assumed, and the disaster plan should provide for some laboratory support capability.
2. Upon initial notification of a mass casualty disaster, a contingency plan for mobilization of the team should be made. Actual mobilization should occur only after an official invitation from the host country has been received. Although well intended, efforts by relief teams not officially invited to a disaster site may actually impair the ability of the local medical community to provide care to the injured, by diverting attention and scarce resources away from the patients.
3. A rapid, safe and dependable means of transportation should be available for initial movement of the burn team and for subsequent resupply as necessary.
4. An effective communication link should be established between the burn team and their home base. In this case, a microwave satellite telephone link provided by the US Department of the Interior proved invaluable in arranging for additional personnel and supplies.
5. Sufficient personnel, supplies and equipment should be allocated to provide effective care at the scene. The team's materials should include monitoring devices, surgical supplies, intravenous fluids, laboratory supplies and necessary medicines. The ultimate goal is to provide a level of care comparable to that achievable by the assistance team in their home country.
6. Financial support should provide the necessary funds for transportation, equipment and supplies as well as team salary support and rations.

Table I. Antibiotic resistance

Antibiotic	*Gram negative (strains resistant/total)*	*Gram positive (strains resistant/total)*
Methicillin	—	117/159
Gentamicin	53/95	—
Ceftazidime	5/75	—
Amikacin	1/75	8/39
Vancomycin	—	0/39

Table II. Costs associated with the mission

	Cost ($)
Supplies	320 000
Equipment	48 000
Communications	8 000
Personnel travel	60 000
Total	436 000

Conclusions

This mission exemplifies the effective use of military resources to provide specialized burn care at a remote site in a timely manner following an accident that generated more burn casualties than local or national medical resources could handle efficiently. The recommendations based on our experience in Ufa will increase the efficiency and effectiveness of future missions providing assistance to burn patients following a natural or manmade disaster.

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